RODS AND SECTIONS

I.C.I METALS LTD
WITTON BIRMINGHAM

RODS AND EXTRUDED SECTIONS

Engineers
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IMPERIAL CHEMICAL INDUSTRIES LIMITED

Published by

I.C.I. METALS LIMITED

(A subsidiary company of Imperial Chemical Industries Limited)

WITTON, BIRMINGHAM, 6

One of the shops for casting Brass Rod Billets, equipped with electric furnaces of large capacity

RODS AND SECTIONS

In this book an attempt is made to give information to the buyer of rods and sections in non-ferrous metals and alloys so that he may know how this product is made, what properties are possessed by the various qualities of rod, and how he may obtain a product best suited to his particular purposes.

I.C.I. METALS LIMITED

(A subsidiary company of Imperial Chemical Industries Limited)

incorporating

KYNOCH LTD.
THE KING'S NORTON METAL COMPANY
ELLIOTT'S METAL CO. LTD.
MUNTZ'S METAL COMPANY
THE HUGHES STUBBS METAL CO.
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INTRODUCTION

THE buyer of semi-manufactured material does not always purchase on price or quality alone, particularly when material of the nature of rods and sections of non-ferrous metals is concerned.

He requires, also, an assurance that the concern to whom he entrusts his order is properly equipped both by experience and with plant to supply him with a product that reaches the highest possible standard of consistent quality.

Rods and sections are usually employed for other manufactures, frequently intricate and requiring metal of flawless quality, as often upon the strength of the finished article will depend the efficient running of costly plant and even the safety of life itself.

In order to assure prospective buyers that I.C.I. Metals Ltd. possess manufacturing experience and plant that ensure the high standard of product they demand, opportunity is taken in this introduction to state that I.C.I. Metals Ltd., the publishers of this book, are an integral part of the world-wide organisation of Imperial Chemical Industries Ltd. There is no organisation in the world producing non-ferrous metals which is so complete and up to date in regard to its technical and manufacturing resources. I.C.I. Metals Ltd. embody several old-established companies, all of which have reached a foremost position in the non-ferrous metal field through the high standard of their manufactures. Their names are well known to every user of metals and they have brought with them into the organisation of I.C.I. Metals Ltd. specialised experience extending as far back as 1755.

The whole of the goodwill of these constituent companies, in the sense that goodwill is understood to be that which causes a satisfied customer to return to the source which has served him well, is maintained and retained within the organisation of I.C.I. Metals Ltd.

Therefore, to the buyer of non-ferrous metals of all kinds, and particularly of rods and sections, since they are the main concern of this booklet, I.C.I. Metals Ltd. extend an assurance that within their own organisation they include fully qualified technical personnel and up-to-date plant that is without equal, both combining to supply a product that reaches a consistently high standard of quality throughout.

ROD

THE original method of manufacturing rod consisted of casting a billet of suitable length and weight and then rolling this billet on a series of rolls having grooves of circular, oval or diamond section, which gradually reduced the billet to the required size.

When accurate dimensions were necessary the rod was given a cold draw on a drawbench.

In a variation of this process an ingot was cast first of all, which was then rolled and subsequently slit into bars of square cross-section, after which the bars were drawn down to size in successive operations on a drawbench.

The rolling method is still employed for some classes of rod, and for certain work rolled rod is still specified officially, but to a large extent the rolling process for producing rod in non-ferrous metals and alloys has been superseded by what is known as the extrusion process.

I.C.I. Metals Ltd., having the experience behind them of such concerns as the King's Norton Metal Company, British Copper Manufacturers Ltd., Elliott's Metal Co. Ltd., Muntz's Metal Company, Allen Everitt & Sons Ltd., the Broughton Copper Company Ltd., etc., are specialists in the manufacture of rod, both by the rolling process and by extrusion, and the illustrations given in this booklet are of typical plant of both kinds at work in I.C.I. factories.

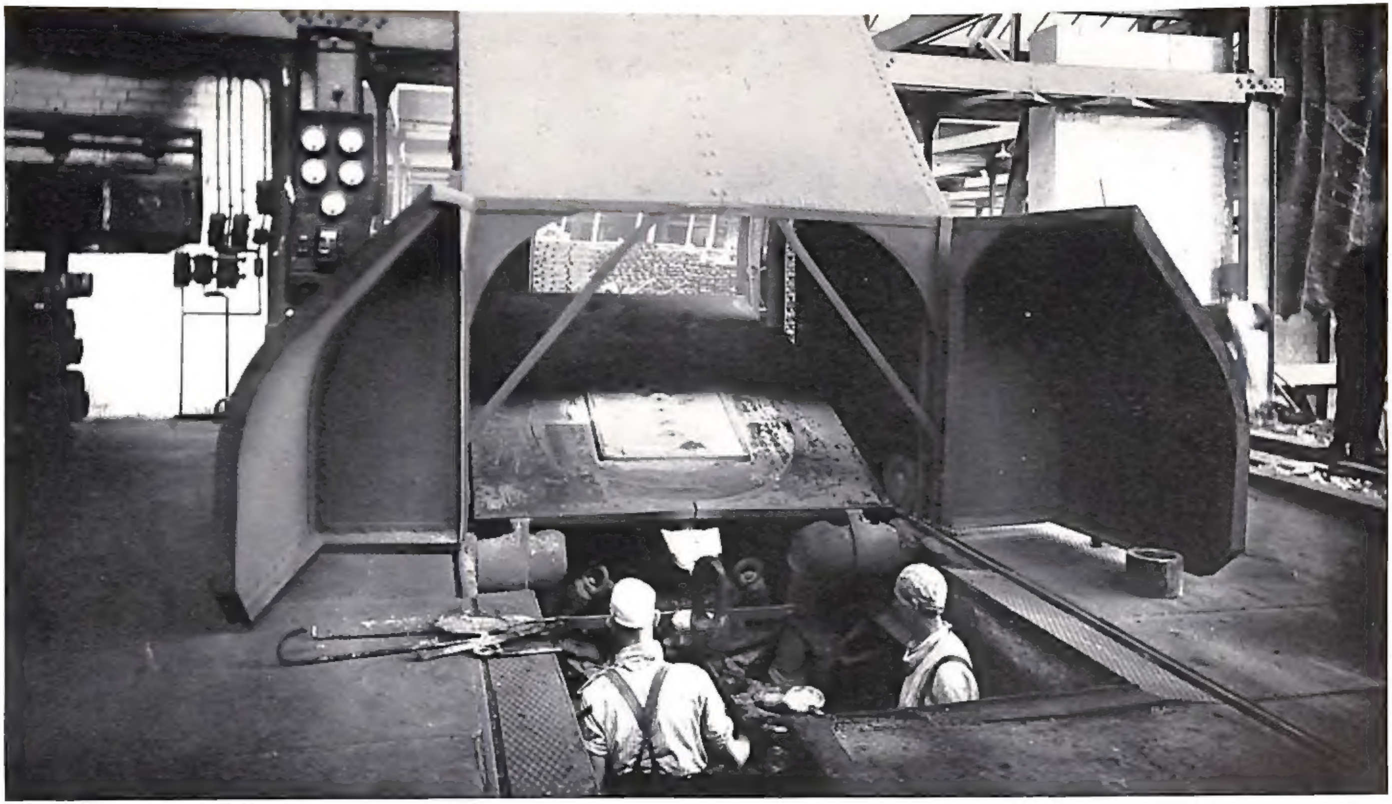
ROLLED ROD

The rolling of copper and its alloys in this country can be traced back to mediaeval times, and the production of rod by rolling is one of the earliest operations associated with the non-ferrous metal industry.

The rolling process held the field for the production of rod until the introduction of the extrusion process, of which more is said later.

Rolled rod is still preferred by certain buyers, and for this reason provision has been made at the factories of I.C.I. Metals Ltd. for the production of rod by both processes, and the plant at their disposal can adequately deal with any demand which may arise.

The relative merits of rolled and extruded rods for certain applications have frequently been the subject of discussion, but,



Pouring Rod Billets from one of the electric melting furnaces

as manufacturers, I.C.I. Metals Ltd. can only assure their customers that their requirements for rod, rolled or extruded, of the most exacting description both as to quality and delivery, can be filled satisfactorily.

EXTRUDED ROD

The process of extruding metal, or the forcing of metal while in a plastic condition through an orifice of suitable cross-section, was invented at the end of the eighteenth century, and was applied to the manufacture of lead pipes in continuous lengths, but fully 100 years elapsed before the process became a practical proposition as far as brass was concerned.

THE MANUFACTURE OF ROD DESCRIBED

A brief description is given below of the plant and methods employed in the factories of I.C.I. Metals Ltd. in the production of rod by both rolling and extrusion.

Casting

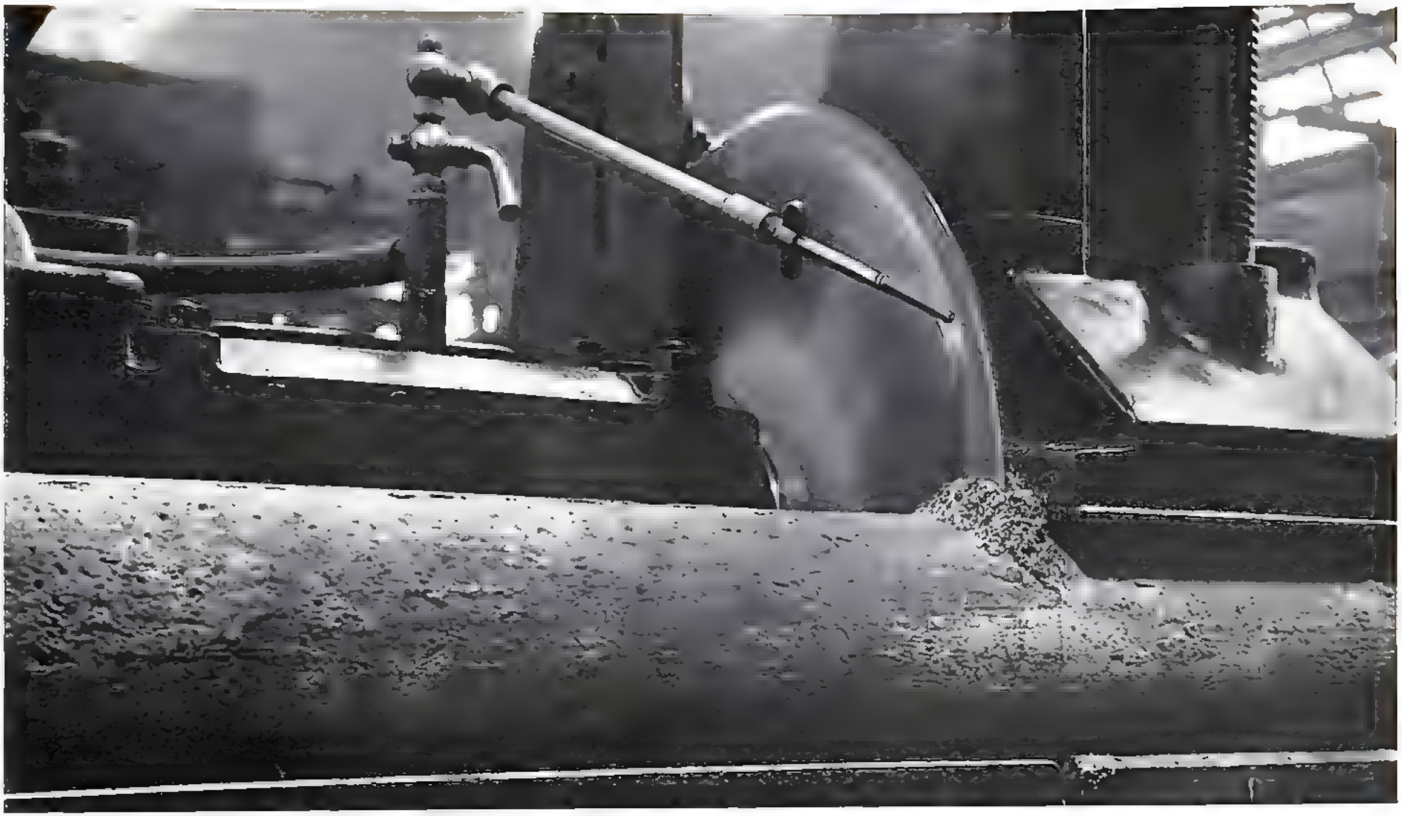
In furtherance of the policy adopted at these works of applying the latest scientific principles to manufacture, and encouraged by the results obtained in casting brass strip from electric furnaces, the electric method of melting has also been applied to the casting of rod billets.

The advantages of electric melting over the older crucible or pit fire method are many. Perhaps the greatest benefit results from the much closer control possible in respect of composition, a degree of accuracy being secured which was quite impossible with the older methods of melting. A further important benefit is greater soundness and uniformity in the billets and consequently cleaner and more homogeneous rod.

Before leaving casting, it should be mentioned that in this process methods have been evolved in the I.C.I. foundries by means of which the possibility of the inclusion of free iron and other objectionable impurities is reduced to a minimum.

Billet Cutting

After removal from the mould, the billets are taken by crane and conveyor to high speed cutting-off machines, where the "gates" are removed and where they are cut into smaller units as required, whence they are taken to store or sent forward to the billet-heating furnaces preparatory to the rolling or extrusion operation.



Sawing Billets into suitable weights for Rod manufacture

Billet Heating

The heating of billets is an operation demanding very careful control, as upon the temperature of the metal depends to a large extent the success or failure of subsequent operations.

Billets of different compositions demand different temperatures of working, and the furnaces must of necessity be maintained within narrow temperature limits. For this reason all billet-heating furnaces in I.C.I. factories are controlled pyrometrically.

Rolling Rod

The rod rolling process consists of passing a red-hot billet through a series of grooved rolls, the size of which diminishes gradually, these graduations being very carefully worked out so as to give uniformity of product and rod of the correct physical properties.

In the case of some alloys, however, it is necessary to conduct the whole of the rolling process in the cold, as if worked hot they either break up or are otherwise unsuitable for such treatment. Here again the rolling is conducted on grooved rolls decreasing in size with each process.

Durin' .old rolling it is necessary, of course, to anneal the material between each operation or series of operations in similar fashion to that associated with the rolling of sheet or strip.

The Extrusion Process

About 1894 Mr. Alexander Dick, of Glasgow, introduced a process for the extrusion of brass and other copper alloys, a development which coincided with that of the capstan and automatic lathes in the manufacture of small articles in brass which had hitherto been made by casting in sand.

In present-day practice for producing extruded rod, the red-hot billet is placed in a thick-walled steel container situated in the body of a hydraulic press. The holder for the die through which the brass is forced is located at the mouth of the container. Operating within the container is a steel ram which is actuated by hydraulic pressure. After the billet has been placed in its container and the die locked in position, pressure is applied, and the ram pushes the plastic billet through the die orifice. When the ram has proceeded to the full extent of its stroke, the pressure is released and, by the action of reversing gear, the ram returns to its original position.

Billets entering preheating furnace

Sizing

After rolling or extrusion, the rod, if necessary, is passed to the drawbenches. The drawing operation is carried out when material to fine dimensional limits is required, or where physical properties of special nature are necessary and attained by such cold work.

A point to be mentioned in connection with this process is the demand for material of much finer dimensional limits than was customary a few years ago. The old ideas of the tolerances permissible on rolled or extruded rod must now be regarded as obsolete, and work is produced to much finer limits, although not specified in the orders received.

A table is given on p. 37 in this booklet showing the limits to which rods are ordinarily manufactured.

Occasionally it is necessary to work to limits even finer than these, and in such circumstances very careful control of the final drawing operation is essential. This will explain to our customers the reason why rod manufactured to close limits of dimensional accuracy is a little more costly than that made to ordinary commercial limits.

Reeling and Straightening

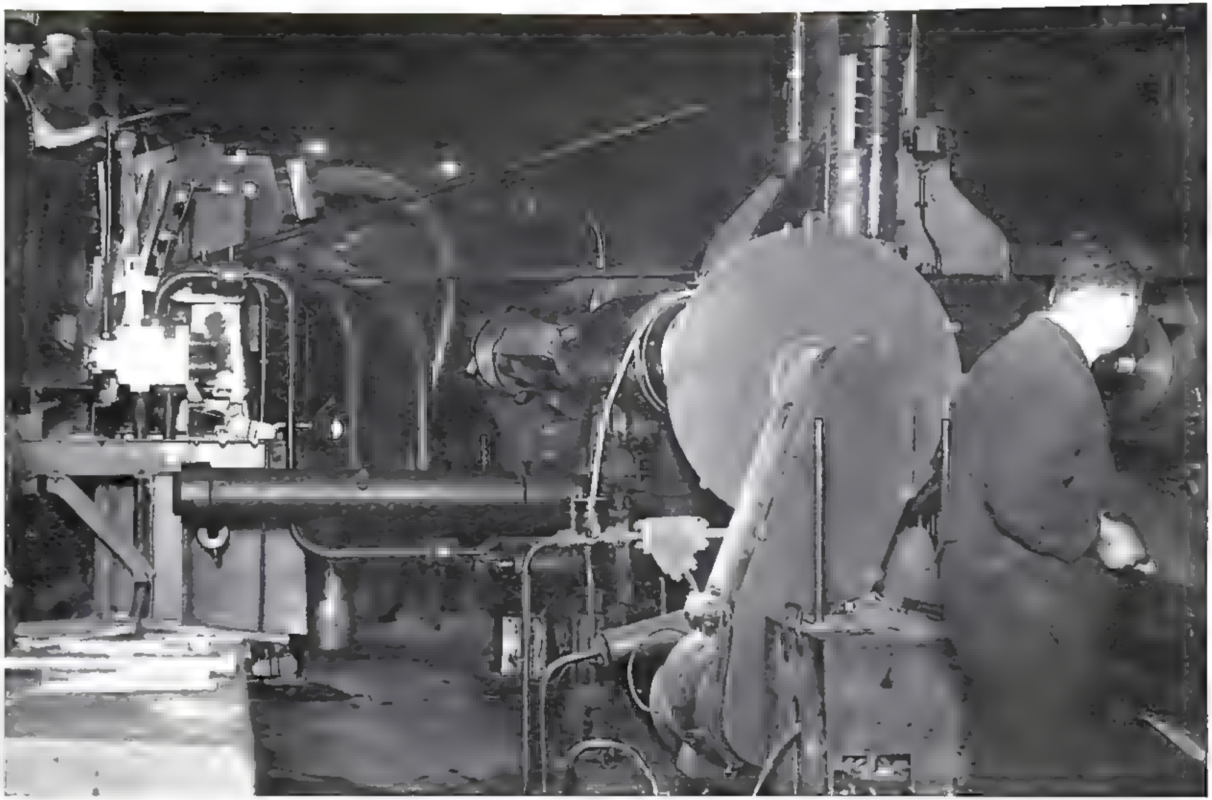
Except in special circumstances, rods prior to despatch are passed through a machine which automatically straightens them.

It has been found that brass rods, whether produced by extrusion or any other process and subsequently drawn, have under certain conditions of storage a tendency to "season crack" in the course of time unless the stresses are removed by some method such as low temperature heat treatment or by mechanical means.

Should the drawn rod not receive further treatment, and particularly if certain gases, such as ammonia, be present in the atmosphere to any extent, corrosive action takes place at the bond between the metallic crystals of the brass, which becomes weakened to such an extent that the internal stresses cannot be restrained, and, releasing themselves, cause disruption of the rod.

For this reason brass rod, except when it is for use in certain special applications, is either low temperature annealed or passed through a "reeling" machine after manufacture. This machine acts in a dual capacity. By bending the rod backwards and forwards it relieves the internal stresses set up during manufacture, rendering it practically immune from "season cracking," and, finally, it straightens the rod.

Rod so treated can be stored without danger of splitting.



Extruding Brass Rods

METALS AND ALLOYS USED IN ROD MANUFACTURE

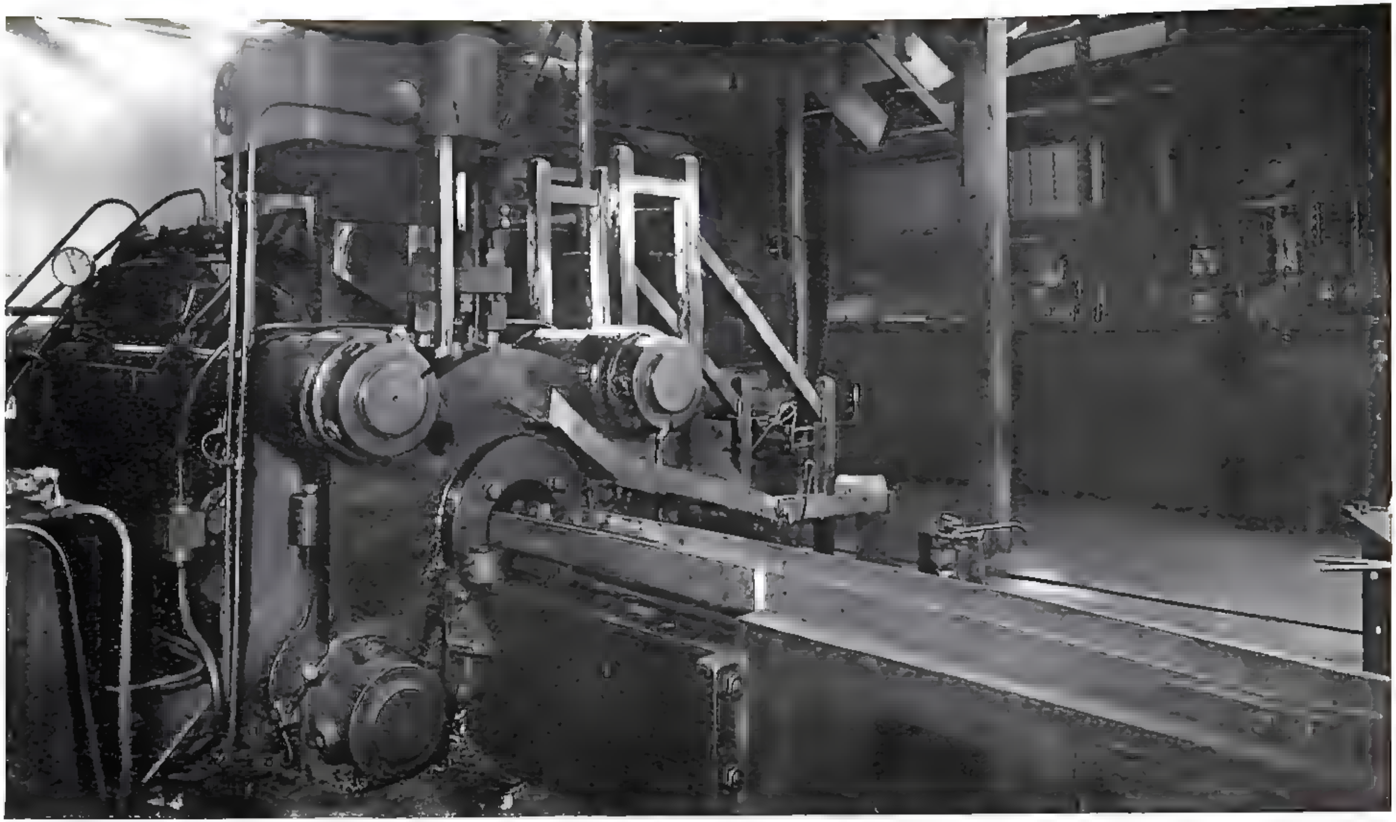
The most commonly used materials in the manufacture of rod are copper and brass. Several types of copper are produced in rod form, chiefly "high-conductivity" for electrical purposes, and arsenical copper for locomotive and general engineering work. The term "brass" includes a great number of mixtures of copper and zinc containing upwards of 50 per cent. of copper. These copper-zinc alloys may be roughly divided into (1) alpha brasses, i.e. those containing more than about 63 per cent. of copper; and (2) alpha-beta brasses, or those containing from about 53 to 63 per cent. of copper. The latter class constitutes the bulk of the demand for brass in rod form. From a metallurgical point of view, the alpha brasses consist of aggregates of crystals of one type, while those of the alpha-beta type are composed of groups of dissimilar crystals.

The properties of the finished rod depend largely upon the methods employed in production, but other metals are sometimes added to the alloys in order to ensure special properties. For instance, rod to be used for free turning usually contains about 3 per cent. of lead, while, in other instances, elements such as tin, manganese, nickel or iron may be added in order to obtain increased strength or other special requirements.

A reference to pages 21, 23 and 25 will indicate clearly the wide variety of brass rod alloys required to fill the needs of modern industry. In addition to these qualities a number of alloys containing variations from standard is manufactured by the company to meet customers' particular requirements or conditions.

Apart from the brass series, special alloys are now also employed, the composition of which fits them for certain definite applications, such as machine parts where resistance to corrosion or heat is essential, coloured work, etc. Examples of these newer alloys are manganese-bronze, aluminium-bronze, nickel-bronze, "Everdur," "Kunial" and "Kuprodur."

While the above holds good for the properties of alloys as determined by their composition, it should not be forgotten that considerable modification of the physical properties of all these alloys can be effected to suit particular requirements by appropriate cold work or heat treatment.



A Brass Rod Extrusion Press

USES OF ROD

Rods, strips and sections in brass and similar materials are manufactured today in an endless variety of shapes and sizes to suit the requirements of different trades and consumers, and a brief summary is given here of the purposes to which this material is now being applied.

The main outlet for copper rods is in the locomotive industry, which absorbs large quantities for firebox stays. In addition to the ordinary round bars of copper, squares are produced for the manufacture of soldering bolts, etc., also hexagons and various sections to supply the demands of the electrical industry.

Reference is made in the following pages to the standard alloys made by I.C.I. Metals Ltd. and to the purposes to which they are particularly well suited.

BRASS PARTS

For small articles such as screws, nuts, pins, bolts, valves, spindles, etc., which are employed in the cycle, motor-car, electrical, and similar trades, and made on automatic and capstan lathes, round, square, flat, and hexagon rod is the accepted material. Rod can be made for use on machines of all kinds up to the most modern automatics running at speeds of 10,000 r.p.m.

Reference to the list on pages 21, 23 and 25 shows that four distinct types of rod are made for turning. In addition to the standard quality, there are the brazing, auto, and red or gunmetal-coloured types, the physical properties of each varying according to the special use to which it is to be applied.

For many purposes, articles hot stamped or pressed from brass rodding have replaced those made by the older method of casting in sand.

HOT STAMPINGS

There is probably no more promising field in the future for brass rod than in the manufacture of motor accessories, electrical goods, and similar articles by hot stamping or pressing. The process involves the manipulation of rod, heated to the appropriate temperature, in a power press or drop stamp, with metal dies of the pattern required. Hot stampings are rapidly replacing small castings, and more recently the process has even been applied to hollow articles, such as bibcocks, gascocks and similar cored casting work. The advantages of hot stamped work over cast parts lie in their finer surface finish, freedom from

A section of the Rod Finishing Department

blowholes, and greater homogeneity and strength; moreover, in repetition work, hot pressed parts can be produced with much less variation in size than was ever possible with castings and in far less time, while the need for surface machining is considerably reduced.

At this point it should be explained that for ease of reference the various products of I.C.I. Metals Ltd. have special code numbers which are given in the tables on pages 21, 23 and 25. In the following pages these products are referred to by their appropriate numbers.

It should be understood that the physical properties given in the tables on pages 21, 23 and 25 are for rods or bars in the normal condition. These properties can be considerably modified by cold work or heat treatment to fulfil special conditions.

For instance, No. 815/CH, the tensile strength of which is given as 30 to 35 tons, can be supplied with physical properties within the range of 30 to 35 tons or 35 to 40 tons, according to customers' requirements, the requisite properties being secured by appropriate cold work.

NOTES ON ALLOYS USED FOR ROD

FREE TURNING ROD

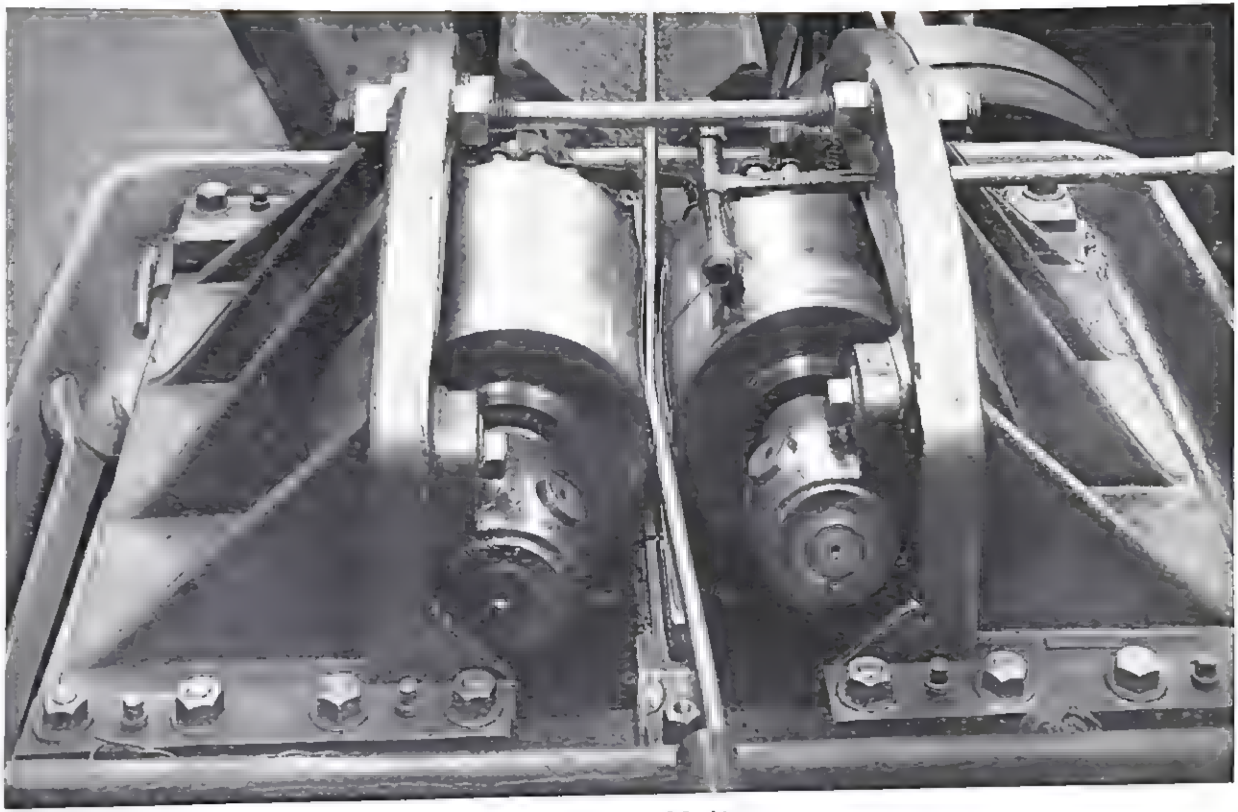
No. 794 is sometimes known as "American" type rod, and is favoured in some quarters for certain particular applications. It contains over 60 per cent. of copper. (See also p. 30, High Speed Turning Rod.)

FOR RIVETING PURPOSES

No. 796, which is recommended for riveting purposes, will also machine and screw well, but not at highest speeds. In rod form it will take a sharp bend. It is particularly suitable for the manufacture of screws.

FOR BENDING PURPOSES

Where small flat sections and strips are required to take a sharp angle, No. 801 is very suitable. This alloy also possesses good machining properties.

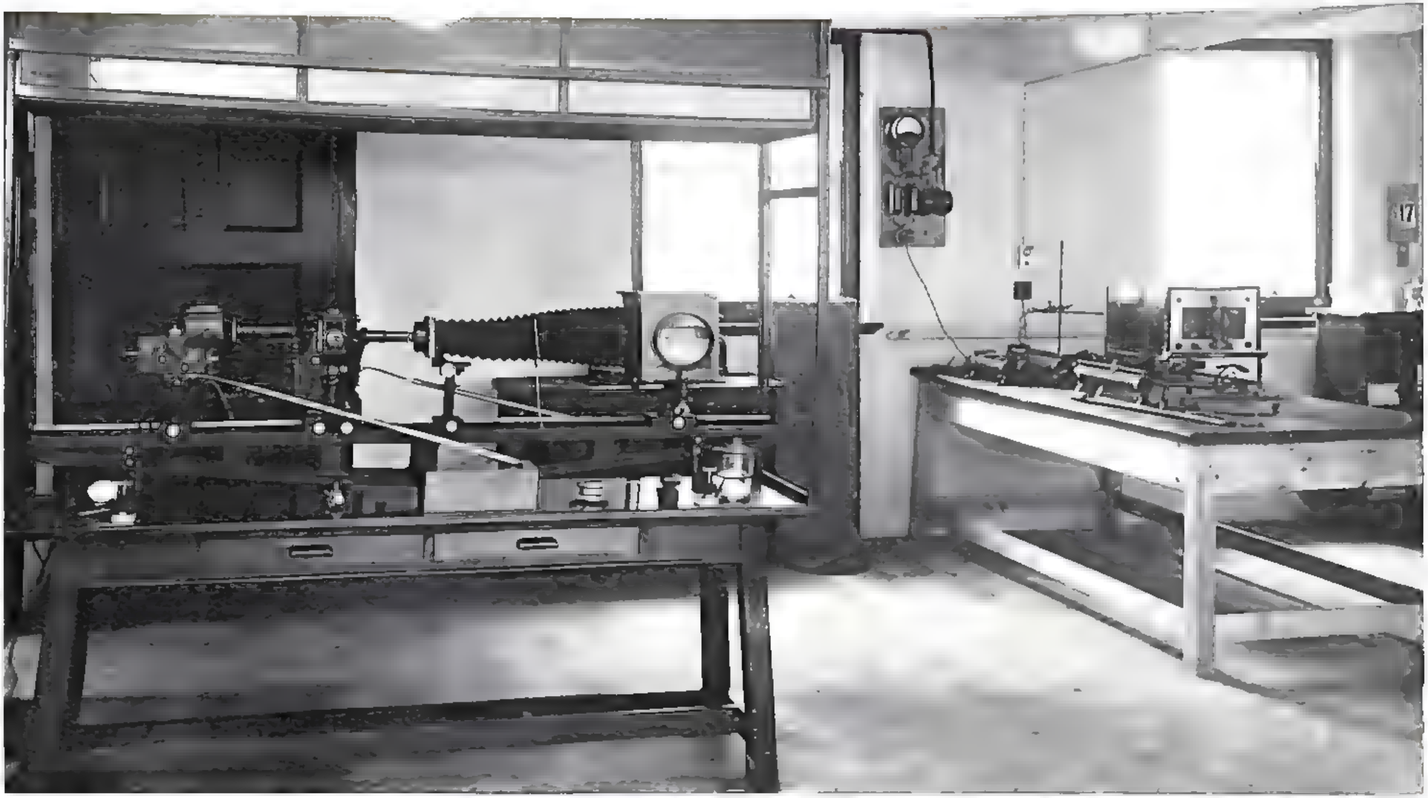


A Rod Reeling Machine

STANDARD QUALITIES OF ROD AND SECTIONS PRODUCED BY I.C.I. METALS LTD.

AND SUBSIDIARY COMPANIES

Code No.	Description	Physical Properties (*as normally supplied*) Tensile Strength (Tons per sq. in.)	Elongation (Per cent.)	Uses
794	Free Turning Rod (brazing type) [*See also Nos.* 803 & 810]	23–25	20–30%	A high quality rod for high-speed turning and screwing; also used for brazing.
795	Small Section Metal	25–27	20–25%	Used for general section work. Has a fine golden yellow colour.
796	Riveting Quality	23–25	30–40%	A tough quality for riveting purposes. Will machine and screw, but not at highest speeds. Round rods will take a sharp bend.
801	Yellow Metal (60/40 type)	25–28	35–45%	Rods and sections for stamping, riveting and bending. Possesses good hot working properties.
801M	Genuine Muntz's Metal	25–28	35–45%	The original and well-known Muntz's metal for stamping, riveting and bending. A good hot working alloy.
802	Ductile Quality	23–25	30–40%	A ductile rod suitable for cold working, heading, etc.
802A	Nipple Quality	23–25	30–40%	Similar to 802, but containing lead to facilitate machining.
803	Free Turning Rod [*See also Nos.* 794 & 810]	25–27	20–25%	For free turning and screwing. Suitable for use on capstan lathes. Fulfils requirements of B.E.S.A. 249.
803/ST	Forging or Stamping Brass	25–27	25–30%	For the production of hot pressings and stampings generally. Is easily machined.
805	Free Turning Rod	28–30	15–20%	For high-speed turning and screwing where a reddish or gunmetal colour is required.
806	Naval Brass (Commercial) ("Victory" Brand)	22–26	20–25%	A commercial naval brass for shipbuilders' general brasswork; similar to Tobin bronze. Suitable for B.E.S.A. 252.



Micrographic apparatus for the examination of Rod

STANDARD QUALITIES OF ROD AND SECTIONS PRODUCED BY I.C.I. METALS LTD.

AND SUBSIDIARY COMPANIES (*continued*)

Code No.	Description	Physical Properties (*as normally supplied*) Tensile Strength (Tons per sq. in.)	Elongation (Per cent.)	Uses
806/AD	Naval Brass (Admiralty)	22–26	20–25%	Naval brass, to the British Admiralty, Air Board 2B6, and B.E.S.A. 251 specifications.
808	Nickel-Bronze	30–35	20–25%	A white metal rod possessing good free turning qualities. A variant can be supplied which is suitable for stamping and hot pressing. Specially suitable for sanitary fittings.
810	High-speed Free Turning Rod	26–28	15–20%	For high-speed turning and screwing. Specially recommended for use on highest speed automatic lathes.
812	High Tensile Brass	30–35	20–25%	For high-class engineering work. Has great strength and is corrosion-resisting. Can replace iron and mild steel with advantage. Suitable for B.E.S.A. 250, Grade A.
813	High Tensile Brass	42–45	18–22%	Attention is called particularly to the high tensile strength of this material. It will hot stamp and is well suited for fuse work. Suitable for B.E.S.A. 250, Grade B.
815/CH	Manganese-Bronze	30–35	25–30%	An alloy of great strength and toughness, suitable for general engineering purposes. Also used for sections and rods intended for shop window work, etc. Readily takes a rich bronze colour.
816	Aluminium-Bronze (91/9 type)	30–35	25–30%	A corrosion-resisting alloy, suitable for cold working.
1003	Aluminium-Bronze (90/10 type)	30–35	25–30%	For parts working at high steam pressure. Is resistant to corrosion.
1009	Brazing Solder Strip (50/50 type)			Used in hard soldering. Supplied in plain or slotted form.

A portion of the Rod Store and Dispatch Department

STANDARD QUALITIES OF ROD AND SECTIONS PRODUCED BY I.C.I. METALS LTD.

AND SUBSIDIARY COMPANIES (*continued*)

Code No.	Description	Physical Properties (*as normally supplied*)		Uses
		Tensile Strength (Tons per sq. in.)	Elongation (Per cent.)	
701	High-Conductivity Copper	14	40%	For general electrical purposes.
701/B	Arsenical Copper	14½	40%	For locomotive firebox stays and general engineering work. Satisfies requirements of B.E.S.A. specifications 24, 12 and 12a.
741	"Nicro"	14½	40%	For locomotive and general engineering purposes.
—	"Everdur" A (hard drawn)	32–45	15–35%	A high strength copper-silicon-manganese alloy for general engineering purposes.
—	"Everdur" B (hard drawn)	30–35	10–15%	A modified "Everdur" alloy for heavy cold working purposes, viz. cold heading, etc.
—	"Kunial" Brass (drawn and tempered)	40–45	10–20%	The new temper-hardenable alloy for general engineering purposes.
—	"Kunial" Copper (drawn and tempered)	38–42	10–20%	A temper-hardenable alloy for general engineering purposes.

Dispatching Rod by rail

FOR BRASS SECTION WORK

Where a fine golden colour is indispensable, No. 795 is recommended. Sections, flats, tees, angles, etc., are produced in this alloy to very close dimensions and require no further treatment beyond the ordinary drilling and tapping for fixing. This material will also take a moderate bend without distortion.

YELLOW METAL

No. 801 is of the Yellow Metal type. It will machine, although not to the same extent as alloys specially developed for the purpose. It is tough and strong, will rivet and bend well and produce pressings and stampings on which little or no machining is necessary. It can be supplied in rod or section form as required. Yellow Metal is used in the heavy engineering trades for pump rods and similar applications.

GENUINE MUNTZ'S METAL

This alloy was invented over a century ago by Mr. G. F. Muntz, founder of the Muntz's Metal Company, which is now incorporated with I.C.I. Metals Ltd. It enjoys a world-wide reputation in general engineering and shipbuilding circles for its excellent working properties and its corrosion-resisting qualities. To obtain the *genuine* Muntz's Metal specify 801M.

BRAZING SOLDER

No. 1009 is supplied in strip form, usually in small flats about $\frac{3}{8}$ in. $\times$ $\frac{1}{8}$ in. and in straight lengths.

Having a very low melting point, it is specially adapted for use as a hard solder, and is in a more convenient form for many purposes than the pounded solders of similar composition often employed for this purpose.

FOR THE HEAVY ENGINEERING TRADES

Bars, rods, strips and sections are produced in a wide range of alloys, embodying high tensile brasses, Naval brass, Muntz's metal, manganese-bronze, aluminium-bronze, and nickel-bronze, etc., which, owing to their composition, have special properties in regard to strength and freedom from corrosion. They can therefore usefully replace iron or steel in situations where the latter would become useless in a very short time.

Dispatching Rod by road

THE HIGH TENSILE BRASSES

No. 812 is typical of these and is employed where great strength is necessary. This material can be manufactured to give a yield point of over 20 tons per square inch, with a tensile strength of over 40 tons and an elongation of not less than 20 per cent. It is therefore suitable for engineering work calling for a material equal in strength to a mild steel, and is largely used for valve spindles, etc., of a heavy character in shipbuilding and similar industries.

NAVAL BRASS

This is, generally speaking, made to the British Admiralty specification, and contains 1 per cent. of tin, which is added with the object of improving its corrosion-resisting properties under sea-water conditions. It has many uses in connection with shipbuilding. A commercial grade of this brass, containing a little less tin than that demanded by the Admiralty specification, is also manufactured.

MANGANESE-BRONZE

An exceedingly strong alloy for heavy engineering purposes, which is also used to a considerable extent in naval work. By reason of its high tensile properties it is particularly suitable for valves and pump rods used in situations where the water is foul or of an acid character. Manganese-bronze is also used for heavy bolts, studs, nuts, pins and keys where the use of iron or steel is not permissible. Hot pressings or stampings can be made in manganese-bronze in the same manner as those of brass, and the material can be supplied in rods or sections according to requirements.

It is also suitable for casement work, shop window fronts and general architectural applications where a rich bronze colour is required. It can be supplied in rods or sections.

ALUMINIUM-BRONZE

Nos. 816 and 1003 are true aluminium-bronzes of the copper 90-91, aluminium 9-10 type, and differ entirely from the so-called aluminium-bronzes which contain a large proportion of zinc and are, in reality, aluminium-brasses. They possess a brilliant golden yellow colour, are strong and tough, and comparable in tensile strength with manganese-bronze, but harder than the latter.

An important point with regard to this bronze is that its strength is but slightly affected by moderately high temperatures.

At 300° C., and even at 400° C., the tensile strength and hardness show results superior to those of the ordinary commercial brasses at normal temperatures. Other outstanding properties of the alloy are its resistance to corrosion, particularly from sea-water, and its remarkable resistance to alternating stress or fatigue.

Owing to the somewhat high production cost, its use as a commercial article has not been so general as its properties warrant.

"EVERDUR"

"Everdur" is the registered trade mark covering a series of copper-silicon-manganese alloys which possess many desirable properties. "Everdur" offers the advantage of strength equal to that of steel with corrosion resistance comparable with that of copper. "Everdur" is ductile; possesses high fatigue limit and good machinability; is non-magnetic and non-sparking, easy to work hot or cold and is readily weldable by all commonly used methods.

NICKEL-BRONZE

No. 808 is one of the newer extrusion alloys. It possesses the white colour of some of the nickel-silver alloys. Hot pressings can be made from it which will take intricate detail and a high polish, and are therefore very suitable for plated work. It possesses considerable strength and toughness and its machining properties are very similar to those of the ordinary free turning brasses. The presence of nickel results in appreciably increased anti-corrosive properties.

"KUNIAL" ALLOYS

"KUNIAL" BRASS AND COPPER

The "Kunial" alloys are a range of non-ferrous products which can be strengthened and hardened by simple heat treatment. "Kunial" alloys in the soft condition are malleable and ductile and are easily cold worked into finished products. The soft "Kunial" alloys can be strengthened and hardened by cold working, after which the strength and hardness can be increased further by temper hardening.

HIGH-SPEED TURNING ROD

This is made specially to meet requirements for a rod that will be suitable for work on modern high-speed automatic machines,

and has been remarkably successful in this direction. Tests are made regularly of the rod as manufactured, on specially installed automatic machines running at speeds of 10,000 r.p.m., in addition to the ordinary routine control tests.

LOCOMOTIVE STAY RODS

I.C.I. Metals Ltd. are large manufacturers of copper and copper alloy rods for locomotive firebox stays in arsenical, non-arsenical, tough pitch or deoxidised copper. Material can be supplied to all recognised specifications—British, Colonial or foreign.

The well-known "Nicro" range of copper alloys, produced by Elliott's Metal Co. Ltd., a subsidiary company of I.C.I. Metals Ltd., are distinguished for their capacity to retain their physical properties at elevated temperatures, and also for their resistance to corrosion. "Nicro" is specified by many railway companies wherever bad or doubtful water supplies are encountered. The "Nicro" range includes "Nicro," "Nicro B," "Nicro D" and "Nicro E."

Manganese-copper of the 95-5 type should also be included in this section, and this material is preferred in some quarters, particularly by Continental authorities, to the more usual plain copper.

ORDERING ROD

In most cases, reference to the table given on page 42 will show a prospective buyer what type of rod is best suited to his requirements. There may be occasions, however, when material of a special nature is required and the descriptions given do not exactly meet the needs of the case. In such circumstances, the buyer should give with his inquiry:

(*a*) An indication of the purpose for which the rod is required and, if possible, a description of the article to be produced.

(*b*) Limits of accuracy for the size given.

(*c*) Any additional information which would assist in determining the composition and necessary physical properties of the rod to be supplied.

In all cases, it is an advantage for an inquiry to be accompanied by a sample of material suitable for the purpose in view.

SPECIFICATION WORK

In addition, I.C.I. Metals Ltd. are prepared to supply rods or sections to any recognised specifications, such as those of the

War Office, Admiralty, Air Board, British Engineering Standards Association, etc., and to British, Colonial, Continental and American railway and customers' own specifications.

EXTRUDED SECTIONS

Following the development of the process of working brass by forcing the plastic metal through a die of circular or square cross-section, a great industry has grown up of producing bars of irregular section to suit various trades. The advantage of the extrusion process for this purpose over the old method of forming from the bar or rod and machining to shape is self-evident.

However intricate, sections can be produced wherever dies of the requisite contour can be made. The section is produced by a simple extrusion process; no machining whatever is necessary. Indeed, the section obtained is superior in appearance and finish to that produced by the original method, while an enormous saving in time and expense is effected.

The large range of sections made by I.C.I. Metals Ltd. is well illustrated in our special catalogue *Extruded Sections*. It is suggested that in this range it is usually possible for customers to find a standard section which adequately fills all their requirements, thus avoiding the expense occasioned by the design and manufacture of tools for special sections.

This catalogue is available on request.

TECHNICAL EQUIPMENT AND SERVICE

It is now recognised that the assistance of properly equipped and efficiently staffed metallurgical laboratories is essential to an establishment of any pretensions engaged in the production of copper, brass and similar alloys.

I.C.I. Metals Ltd. are particularly well situated in this respect. In addition to a fully trained personnel and up-to-date equipment for routine chemical analysis and physical testing, there are well-equipped separate departments for carrying out the research and general investigation work which is essential in a modern factory.

The close collaboration which is maintained in the works of I.C.I. Metals Ltd. between the laboratory and manufacturing departments enables them to give their customers the full benefit of their resources in plant and personnel, and enquiries are cordially invited from customers, actual or prospective, regarding their difficulties or requirements generally.

DELIVERY

Realising the paramount importance of prompt delivery to consumers of rod, I.C.I. Metals Ltd. make this feature an essential part of their service. Large stocks in all qualities, shapes and sizes are always available for quick transport to every part of the country or the world. For local area deliveries there is a fleet of lorries, while for distant consignments I.C.I. Metals Ltd. have their own railway sidings linking up with the great railway systems of the country.

LIST OF TABLES

appearing in the following pages

The tables giving weights of rod, etc., are based on metals and alloys of known specific gravity.

It is possible, therefore, to obtain corresponding weights for any other metal or alloy whose specific gravity is known by multiplying the weight given in the tables by the appropriate factor for specific gravity correction:

$$W = w \times \frac{K}{8 \cdot 89}$$

W = weight required for metal or alloy of specific gravity K.
w = weight given in the tables for copper.

TABLE No. 1

VARIATIONS OF SPECIFIC GRAVITY OF BRASS WITH COMPOSITION

Composition			Specific Gravity	Factor
Cu	Zn	Pb		
70·0	30·0	—	8·50	1·006
68·0	32·0	—	8·48	1·004
67·0	33·0	—	8·45	1·000
62·0	37·8	0·2	8·44	0·999
61·0	36·0	3·0	8·47	1·002
60·0	39·5	0·5	8·42	0·996
59·0	37·5	3·5	8·49	1·005
58·5	41·5	—	8·39	0·993
57·5	40·0	2·5	8·45	1·000

TABLE No. 2

WEIGHT PER LINEAL FOOT OF COPPER AND BRASS ROD

Size Inches	COPPER		BRASS		
	Round lb.	Square lb.	Round lb.	Square lb.	Hexagon lb.
$\frac{1}{4}$	·20	·25	·182	·232	·201
$\frac{5}{16}$	·30	·40	·284	·362	·313
$\frac{3}{8}$	·45	·55	·410	·521	·452
$\frac{7}{16}$	·60	·75	·557	·710	·615
$\frac{1}{2}$	·75	·95	·728	·927	·803
$\frac{9}{16}$	·95	1·25	·921	1·17	1·02
$\frac{5}{8}$	1·20	1·50	1·14	1·45	1·25
$\frac{11}{16}$	1·45	1·85	1·38	1·75	1·52
$\frac{3}{4}$	1·70	2·20	1·64	2·09	1·81
$\frac{13}{16}$	2·00	2·55	1·92	2·45	2·12
$\frac{7}{8}$	2·35	2·95	2·23	2·84	2·46
$\frac{15}{16}$	2·65	3·40	2·56	3·26	2·82
1	3·05	3·90	2·91	3·71	3·21
$1\frac{1}{8}$	3·85	4·90	3·69	4·69	4·06
$1\frac{1}{4}$	4·75	6·05	4·55	5·79	5·02
$1\frac{3}{8}$	5·75	7·35	5·51	7·01	6·07
$1\frac{1}{2}$	6·85	8·75	6·55	8·34	7·22
$1\frac{5}{8}$	8·05	10·25	7·69	9·79	8·48
$1\frac{3}{4}$	9·35	11·90	8·92	11·4	9·83
$1\frac{7}{8}$	10·70	13·65	10·2	13·0	11·3
2	12·20	15·55	11·6	14·8	12·8
$2\frac{1}{8}$	13·75	17·55	13·2	16·7	14·5
$2\frac{1}{4}$	15·40	19·65	14·7	18·8	16·3
$2\frac{3}{8}$	17·20	21·90	16·4	20·9	18·1
$2\frac{1}{2}$	19·05	24·25	18·2	23·2	20·1
$2\frac{5}{8}$	21·00	26·75	20·1	25·5	22·1
$2\frac{3}{4}$	23·05	29·35	21·0	28·0	24·3
$2\frac{7}{8}$	25·20	32·10	24·1	30·6	26·5
3	27·45	34·95	26·2	33·4	28·9
$3\frac{1}{4}$			30·8	39·2	33·9
$3\frac{1}{2}$			35·7	45·4	39·3
$3\frac{3}{4}$			41·0	52·1	45·2
4			46·6	59·3	51·4
$4\frac{1}{4}$			52·6	67·0	58·0
$4\frac{1}{2}$			59·0	75·1	65·0
$4\frac{3}{4}$			65·7	83·7	72·5
5			72·8	92·7	80·3
$5\frac{1}{4}$			80·3	102·2	88·5
$5\frac{1}{2}$			88·1	112·2	97·1
$5\frac{3}{4}$			96·3	122·6	106·2
6			104·8	133·5	115·6

To find the weight in pounds per lineal foot of rod of any diameter not given in the above table, multiply the value of C given in the table below for the particular metal by the square of the diameter of the rod expressed in inches and decimals of an inch.

C	Copper	Brass
	3·05	2·91

Thus the weight per lineal foot of a copper rod 2·08 in. in diameter is $3{\cdot}05 \times (2{\cdot}08)^2$ or 13·2 lb.

Square rods are 1·273 times heavier than round rods when the side of the square is equal to the diameter of the round rod.

Hexagon rods are 1·1027 times heavier than round rods when the dimension across the flats is equal to the diameter of the round rod.

To obtain the weight in kilogrammes per lineal metre, multiply the above figures by 1·488.

TABLE No. 3

WEIGHTS OF BRASS HEXAGON BARS (WHITWORTH STANDARD NUT SIZES)

Size	Width across flats	Weight (lb. per foot)	Weight (kgs. per metre)
	in.	lb.	kilogrammes
$\frac{1}{8}$	0·338	0·367	0·546
$\frac{3}{16}$	0·448	0·645	0·960
$\frac{1}{4}$	0·525	0·884	1·32
$\frac{5}{16}$	0·601	1·16	1·73
$\frac{3}{8}$	0·709	1·61	2·40
$\frac{7}{16}$	0·820	2·16	3·21
$\frac{1}{2}$	0·919	2·71	4·03
$\frac{9}{16}$	1·011	3·28	4·88
$\frac{5}{8}$	1·101	3·89	5·79
$\frac{11}{16}$	1·201	4·63	6·89
$\frac{3}{4}$	1·301	5·43	8·08
$\frac{13}{16}$	1·390	6·20	9·23
$\frac{7}{8}$	1·479	7·02	10·4
$\frac{15}{16}$	1·574	7·95	11·8
1	1·670	8·96	13·3
$1\frac{1}{8}$	1·860	11·1	16·6
$1\frac{1}{4}$	2·048	13·5	21·1
$1\frac{3}{8}$	2·214	15·8	23·4
$1\frac{1}{2}$	2·413	18·7	27·8
$1\frac{5}{8}$	2·576	21·3	31·7
$1\frac{3}{4}$	2·757	24·4	36·3
$1\frac{7}{8}$	3·018	29·2	43·5
2	3·149	31·9	47·5
$2\frac{1}{4}$	3·546	40·4	60·1
$2\frac{1}{2}$	3·894	48·7	72·3
$2\frac{3}{4}$	4·181	56·1	83·5
3	4·531	65·9	98·1

TABLE No. 4

ACCURACY LIMITS FOR ROUND, HEXAGON AND SQUARE BARS

(Conforms to British Engineering Standards Specification for Brass Rod)

Nominal Size of Bar (diameter or width across flats)		Accuracy Worked to		
		Extruded	Rolled	Drawn (after extrusion or rolling)
Inches	Mm.	Margin of Manufacture	Margin of Manufacture	Margin of Manufacture
		Plus or Minus	Plus	Minus
		in.	in.	in.
$\frac{1}{4}$ (0·25)	6·35	0·002	0·010	0·002
$\frac{5}{16}$ (0·3125)	7·94	0·002	0·010	0·002
$\frac{3}{8}$ (0·375)	9·53	0·002	0·010	0·002
$\frac{7}{16}$ (0·4375)	11·11	0·002	0·010	0·002
$\frac{1}{2}$ (0·5)	12·70	0·003	0·010	0·002
$\frac{9}{16}$ (0·5625)	14·29	0·003	0·010	0·002
$\frac{5}{8}$ (0·625)	15·88	0·003	0·010	0·002
$\frac{3}{4}$ (0·75)	19·05	0·003	0·010	0·002
$\frac{7}{8}$ (0·875)	22·23	0·003	0·010	0·003
1	25·40	0·004	0·015	0·003
$1\frac{1}{8}$ (1·125)	28·58	0·004	0·015	0·003
$1\frac{1}{4}$ (1·25)	31·75	0·004	0·015	0·003
$1\frac{3}{8}$ (1·375)	34·93	0·004	0·020	0·003
$1\frac{1}{2}$ (1·5)	38·10	0·005	0·020	0·004
$1\frac{5}{8}$ (1·625)	41·28	0·005	0·020	0·004
$1\frac{3}{4}$ (1·75)	44·45	0·005	0·020	0·004
$1\frac{7}{8}$ (1·875)	47·63	0·006	0·025	0·004
2	50·80	0·006	0·025	0·004

Any bar intermediate between the diameters or sizes given above has the margin of manufacture of the next size larger.

Bars ordered in millimetre sizes take the manufacturing margin of the nearest British equivalent.

Finer limits than the above can be supplied by special arrangement.

TABLE No. 5

CONVERSION FACTORS

English to Metric		
Inches to millimetres	×	25·40
Feet to metres	×	0·3048
Grains to grammes	×	0·06480
Pounds (7,000 grs.) to grammes	×	453·6
Pounds (7,000 grs.) to kilogrammes	×	0·4536
Square inches to square millimetres	×	645·2
Square feet to square metres	×	0·09290
Cubic inches to cubic centimetres	×	16·39
Cubic feet to cubic metres	×	0·02832
Gallons to litres	×	4·546
Pounds per lineal foot to kilos per lineal metre	×	1·488
Pounds per square foot to kilos per square metre	×	4·883
Tons per square inch to kilos per square millimetre	×	1·575
Pounds per gallon to kilos per litre	×	0·09978
Metric to English		
Millimetres to inches	×	0·03937
Metres to feet	×	3·281
Grammes to grains	×	15·43
Grammes to pounds (7,000 grs.)	×	0·002205
Kilogrammes to pounds (7,000 grs.)	×	2·205
Square kilometres to square inches	×	0·001550
Square metres to square feet	×	10·76
Cubic centimetres to cubic inches	×	0·06102
Cubic metres to cubic feet	×	35·31
Litres to gallons	×	0·2200
Kilos per lineal metre to pounds per lineal foot	×	0·6720
Kilos per square metre to pounds per square foot	×	0·2048
Kilos per square millimetre to tons per square inch	×	0·6350
Kilos per litre to pounds per gallon	×	10·02

TABLE No. 6

TEMPERATURE CONVERSION TABLE

Centigrade to Fahrenheit and vice versa

° C.	0	10	20	30	40	50	60	70	80	90
−0	° F. + 32	° F. + 14	° F. − 4	° F. − 22	° F. − 40	° F. − 58	° F. − 76	° F. − 94	° F. − 112	° F. − 130
0	32	50	68	86	104	122	140	158	176	194
100	212	230	248	266	284	302	320	338	356	374
200	392	410	428	446	464	482	500	518	536	554
300	572	590	608	626	644	662	680	698	716	734
400	752	770	788	806	824	842	860	878	896	914
500	932	950	968	986	1004	1022	1040	1058	1076	1094
600	1112	1130	1148	1166	1184	1202	1220	1238	1256	1274
700	1292	1310	1328	1346	1364	1382	1400	1418	1436	1454
800	1472	1490	1508	1526	1544	1562	1580	1598	1616	1634
900	1652	1670	1688	1706	1724	1742	1760	1778	1796	1814
1000	1832	1850	1868	1886	1904	1922	1940	1958	1970	1994
1100	2012	2030	2048	2066	2084	2102	2120	2138	2156	2174
1200	2192	2210	2228	2246	2264	2282	2300	2318	2336	2354
1300	2372	2390	2408	2426	2444	2462	2480	2498	2516	2534
1400	2552	2570	2588	2606	2624	2642	2660	2678	2696	2714
1500	2732	2750	2768	2786	2804	2822	2840	2858	2876	2894
1600	2912	2930	2948	2966	2984	3002	3020	3038	3056	3074
1700	3092	3110	3128	3146	3164	3182	3200	3218	3236	3254
1800	3272	3290	3308	3326	3344	3362	3380	3398	3416	3434
1900	3452	3470	3488	3506	3524	3542	3560	3578	3596	3614
2000	3632	3650	3668	3686	3704	3722	3740	3758	3776	3794

° C.	° F.
1 =	1·8
2 =	3·6
3 =	5·4
4 =	7·2
5 =	9·0
6 =	10·8
7 =	12·6
8 =	14·4
9 =	16·2
10 =	18·0

° F.	° C.
1 =	0·56
2 =	1·11
3 =	1·67
4 =	2·22
5 =	2·78
6 =	3·33
7 =	3·89
8 =	4·44
9 =	5·00
10 =	5·56
11 =	6·11
12 =	6·67
13 =	7·22
14 =	7·78
15 =	8·33
16 =	8·89
17 =	9·44
18 =	10·00

Examples: 852° C. = 1562 + 3·6 = 1565·6° F.
1945° F. = 1060 + 2·78 = 1062·78° C.

Formulae for temperature conversion:
$°C. = (°F. - 32) \times \frac{5}{9}$ $\quad$ $°F. = (°C. \times \frac{9}{5}) + 32$

TABLE No. 7

DECIMAL EQUIVALENTS OF FRACTIONAL PARTS OF AN INCH

Fractions	Decimals	Fractions	Decimals	Fractions	Decimals	Fractions	Decimals
1/64	0·015625	17/64	0·265625	33/64	0·515625	49/64	0·765625
1/32	0·03125	9/32	0·28125	17/32	0·53125	25/32	0·78125
3/64	0·046875	19/64	0·296875	35/64	0·546875	51/64	0·796875
1/16	0·0625	5/16	0·3125	9/16	0·5625	13/16	0·8125
5/64	0·078125	21/64	0·328125	37/64	0·578125	53/64	0·828125
3/32	0·09375	11/32	0·34375	19/32	0·59375	27/32	0·84375
7/64	0·109375	23/64	0·359375	39/64	0·609375	55/64	0·859375
1/8	0·125	3/8	0·375	5/8	0·625	7/8	0·875
9/64	0·140625	25/64	0·390625	41/64	0·640625	57/64	0·890625
5/32	0·15625	13/32	0·40625	21/32	0·65625	29/32	0·90625
11/64	0·171875	27/64	0·421875	43/64	0·671875	59/64	0·921875
3/16	0·1875	7/16	0·4375	11/16	0·6875	15/16	0·9375
13/64	0·203125	29/64	0·453125	45/64	0·703125	61/64	0·953125
7/32	0·21875	15/32	0·46875	23/32	0·71875	31/32	0·96875
15/64	0·234375	31/64	0·484375	47/64	0·734375	63/64	0·984375
1/4	0·25	1/2	0·5	3/4	0·75	1	1·0

TABLE No. 8

SPECIFIC GRAVITY AND MELTING POINT OF SOME COMMON METALS AND ALLOYS

Name	Percentage Composition	Specific Gravity	Melting Point °C.
Aluminium		2·7	658
Aluminium-Bronze	90 Cu, 10 Al	7·6	1050
Antimony		6·7	630
Babbitt Metal	90 Sn, 7 Sb, 3 Cu	7·5	230
Bell Metal	78 Cu, 22 Sn	8·7	890
Bismuth		9·8	271
Brass	60 Cu, 40 Zn	8·3	890
Brass	67 Cu, 33 Zn	8·4	940
Brass	70 Cu, 30 Zn	8·45	950
Britannia Metal	90 Sn, 10 Sb	7·9	260
Cadmium		8·7	321
Cartridge Metal	70 Cu, 30 Zn	8·5	950
Coinage Bronze	95 Cu, 4 Sn, 1 Zn	8·9	900
Constantan	60 Cu, 40 Ni	8·9	1290
Copper		8·9	1083
Cupro-Manganese	70 Cu, 30 Mn	—	—
Cupro-Nickel	80 Cu, 20 Ni	8·9	1190
Cupro-Nickel	70 Cu, 30 Ni	8·9	1220
"Everdur"	96 Cu, 3 Si, 1 Mn	8·5	1019
Gilding Metal	90 Cu, 10 Zn	—	—
Gold		19·3	1063
Gold Coinage	91·7 Au, 8·3 Cu	17·3	951
Gun Metal	88 Cu, 10 Sn, 2 Zn	8·8	1010
"Invar"	64 Fe, 36 Ni	8·0	1500
Lead		11·4	327
Magnalium	90 Al, 10 Mg	2·5	608
Manganese		8·0	1225
Manganese-Bronze	95 Cu, 5 Mn	8·8	1060
Manganese-Bronze	58 Cu, 40 Zn, 2 Mn	8·3	900
Manganin	84 Cu, 12 Mn, 4 Ni	8·5	—
Muntz's Metal	60 Cu, 40 Zn	8·4	—
Naval Brass	61 Cu, 38 Zn, 1 Sn	—	855
Nickel		8·8	1452
Nickel Coinage	75 Cu, 25 Ni	—	—
Nickel-Silvers:			
Best	25 Ni, 58 Cu, 17 Zn	—	—
Firsts	20 Ni, 63 Cu, 17 Zn	—	—
A	18 Ni, 60 Cu, 22 Zn	8·7	1100
Seconds	16 Ni, 59 Cu, 25 Zn	—	—
Thirds	12 Ni, 56 Cu, 32 Zn	—	—
Pewter	80 Sn, 20 Pb	10·0	200
Phosphor-Bronze	95 Cu, 5 Sn	8·8	—
Platinum		21·5	1755
Rose Metal	50 Bi, 27 Pb, 23 Sn	—	94
Silver		10·6	961
Silver Coinage:			
Old	92·5 Ag, 7·5 Cu	10·3	875
New	50 Ag, 40 Cu, 5 Ni, 5 Zn	—	—
Solder	67 Pb, 33 Sn	9·4	240
Tin		7·3	232
Type Metal	82 Pb, 15 Sb, 3 Sn	—	—
White Metal	75 Pb, 19 Sb, 5 Sn, 1 Cu	9·5	240
Wood's Metal	50 Bi, 24 Pb, 14 Sn, 12 Cd	9·7	60
Zinc		7·2	419

TABLE No. 9

USES OF COMMON NON-FERROUS METALS AND ALLOYS

Metal or Alloy	Composition							Applications
	Cu	Zn	Sn	Ni	Al			
H.C. Copper ..	99·90	—	—	—	—	—	—	For electrical work.
Commercial Copper	99·50	—	—	—	—	—	—	For general purposes. Spinning and coppersmith's work, roofing, etc.
Arsenical Copper ..	99·2	—	—	—	—	—	As 0·3–0·5	For locomotive firebox work.
Cap Copper ..	97·0	3·0	—	—	—	—	—	For deep drawing and stamping.
Gilding Metal ..	90·0	10·0	—	—	—	—	—	For jewellers and art metal work.
Cartridge Brass ..	70·0	30·0	—	—	—	—	—	For drawn products generally requiring strength and ductility.
Brass for Presswork	65·0	35·0	—	—	—	—	—	For general press work.
Naval Brass ..	61·0	38·0	1·0	—	—	—	—	For marine uses.
Muntz's Metal ..	60·0	40·0	—	—	—	—	—	For sheets and products not requiring to undergo much deformation in the cold during manufacture. A good hot-working alloy
Yellow Metal ..	58·0	40·0	—	—	—	Pb 2·0	—	For hot working, free turning, etc.
Aluminium-Bronze	91·0	—	—	—	9·0	—	—	For coins, corrosion resistance and general engineering purposes.
"Everdur" ..	96·0	—	—	—	—	Mn 1	Si 3	
Cupro-Nickel ..	95·0	—	—	5·0	—	—	—	For projectile driving bands.
	85·0	—	—	15·0	—	—	—	For electrical work.
	80·0	—	—	20·0	—	—	—	For bullet envelopes and other purposes requiring strength and ductility.
	70·0	—	—	30·0	—	—	—	For corrosion resistance. Specially suitable for condenser tubes.
Nickel-Silver	50–70	10–35	—	7–30	—	—	—	For colour, resistance to corrosion, and electrical resistance purposes.

USEFUL FORMULAE

Cube or rectangular vessel: Volume $=$ length $\times$ breadth $\times$ height.
Triangle: Area $= \frac{1}{2}$ base $\times$ perpendicular height.
Circle: Area $= 0{\cdot}7854 \times (\text{diameter})^2$.
Circumference $= 3{\cdot}1416 \times$ diameter.
Ellipse: Area $= 0{\cdot}7854 \times$ long axis $\times$ short axis.
Sphere: Surface $= 3{\cdot}1416 \times (\text{diameter})^2$.
Volume $= \frac{4}{3} \times 3{\cdot}1416 \times (\text{radius})^3$.
Cylinder or prism: Volume $=$ area of base $\times$ height.
Surface $=$ area of both ends $+$ (length $\times$ perimeter).
Cone or pyramid: Volume $= \frac{1}{3} \times$ area of base $\times$ perpendicular height.
Surface $=$ area of base $+$ (perimeter $\times \frac{1}{2}$ slant height).

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